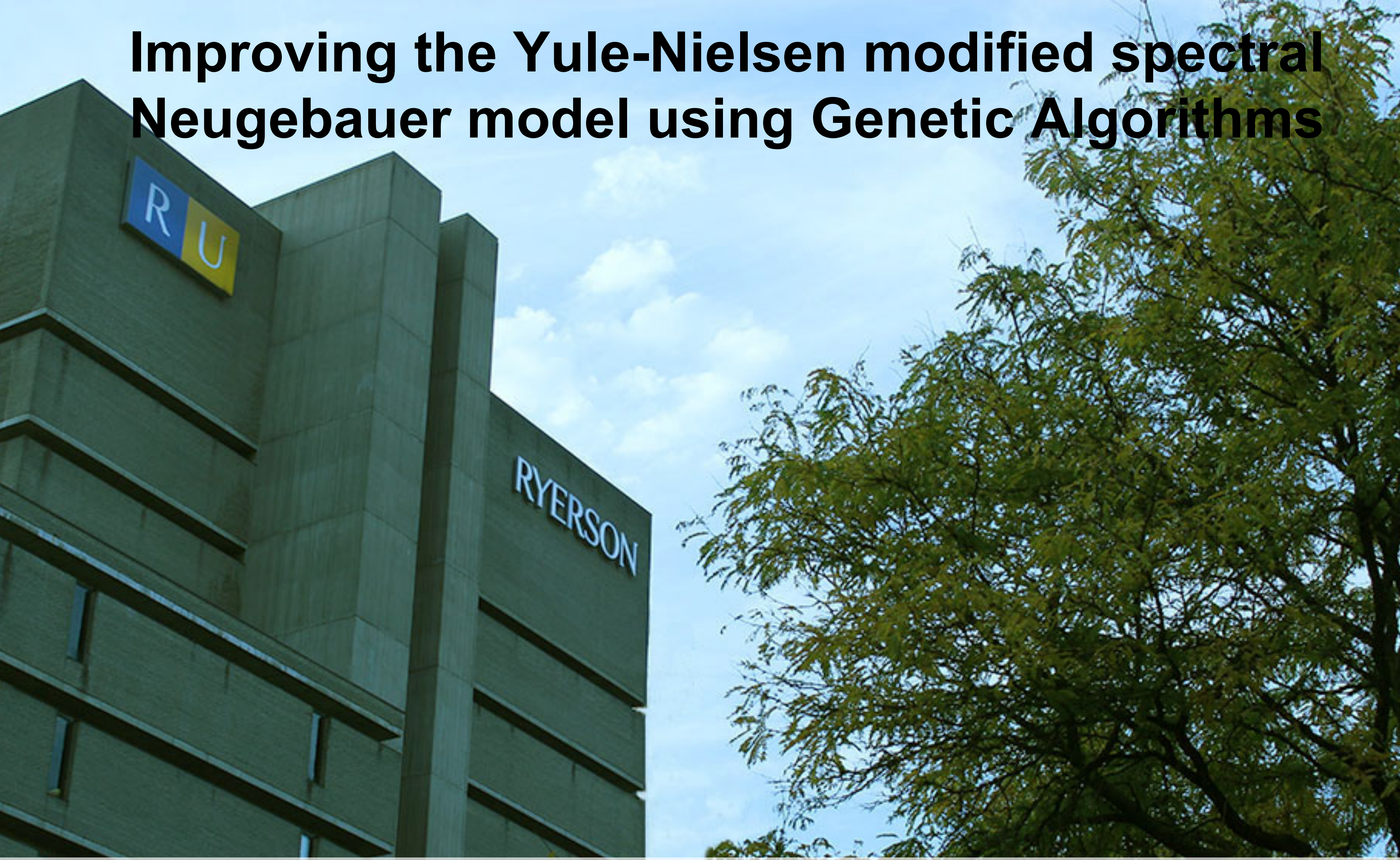
Improving the Yule-Nielsen modified spectral Neugebauer model using Genetic Algorithms



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Outline

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- Yule-Nielsen Modified Spectral Neugebauer (YNSN) Model
- Dot Gain
- Spectral n model
- Genetic Algorithm
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Background

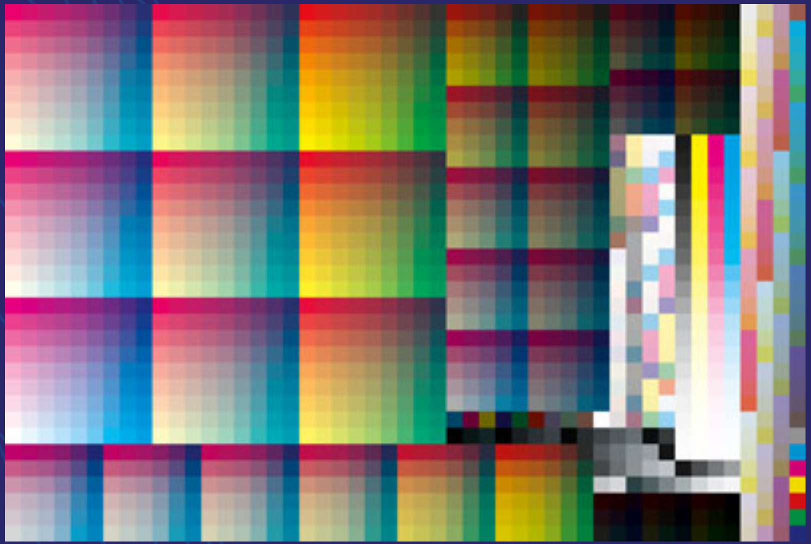
- Yule-Nielsen modified spectral Neugebauer (YNSN) model is widely used in following applications:
  - ICC profile creation
  - Online monitoring and press calibration
  - Benefit:
  - Reduce the number of printing examples
  - High accuracy
  - Easy to update

- Improvements

Improve the model accuracy and flexibility
–propose a method to fine-tune the dot gain
Curve and obtain the Yule-Nielsen factor for each
Wavelength at the same time

- Our approach

–Using genetic algorithm to fine tune the dot
gain and YNSN n factor in a set



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Yule-Nielsen Modified Spectral Neugebauer Model

- It is the most widely used spectral reflection prediction model
- Used limited number of samples to predict unlimited colours

$$R_\lambda = [\sum_{i=1}^{N} F_i R_{\lambda,i}^{1/n}]^n$$

Where
F_i is the fractional area coverage of the Neugebauer Primary colour
$R_{\lambda,i}$ is the measured reflectance
n is the Yule-Nielsen factor
R_λ is the calculated reflectance of the ink mix

$$F_i = \prod_{j=1 \to N}$$ (If ink j is in Neugebauer Primary I, then a_j Else , $(1- a_j)$)

Where
a_j is the effective area coverage of ink j.

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Calculation of the area coverage for each Neugebauer primary given the concentration of inks

Index	Neugebauer Primary (I)	Area Coverage (F_i)
1	W	(1-c)(1-m)(1-y)(1-k)
2	K	(1-c)(1-m)(1-y)k
3	Y	(1-c)(1-m)y(1-k)
4	YK	(1-c)(1-m)yk
5	M	(1-c)m(1-y)(1-k)
6	MK	(1-c)m(1-y)k
7	MY	(1-c)my(1-k)
8	MYK	(1-c)myk
9	C	c(1-m)(1-y)(1-k)
10	CK	c(1-m)(1-y)k
11	CY	c(1-m)y(1-k)
12	CYK	c(1-m)yk
13	CM	cm(1-y)(1-k)
14	CMK	cm(1-y)k
15	CMY	cmy(1-k)
16	CMYK	cmyk

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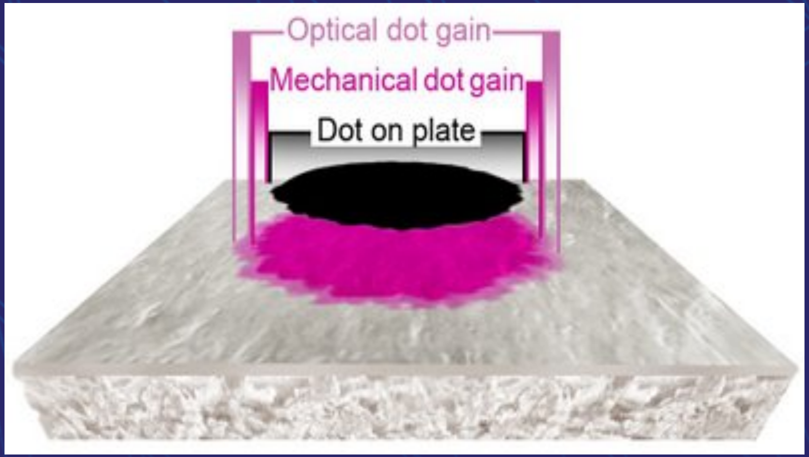
Dot Gain Model

- During the printing process, the ink dots that is dropped on the paper will spread out and increase its size
- Dot Gain consist of mechanical dot gain and optical dot gain (due to the light reflection)
- A linear regression algorithms have been combined with YNSN model to accurately calculate the real dot gain value



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Spectral n Model

- The different wavelength of light propagates and reflects slightly different in the paper and ink
- n value in a range of 0 to 100
- It improves the prediction results
- The spectral n model equation is following

$$R_\lambda = [\sum_{i=1}^{N} F_i R_{\lambda,i}^{1/n_i}]^{n_i}$$

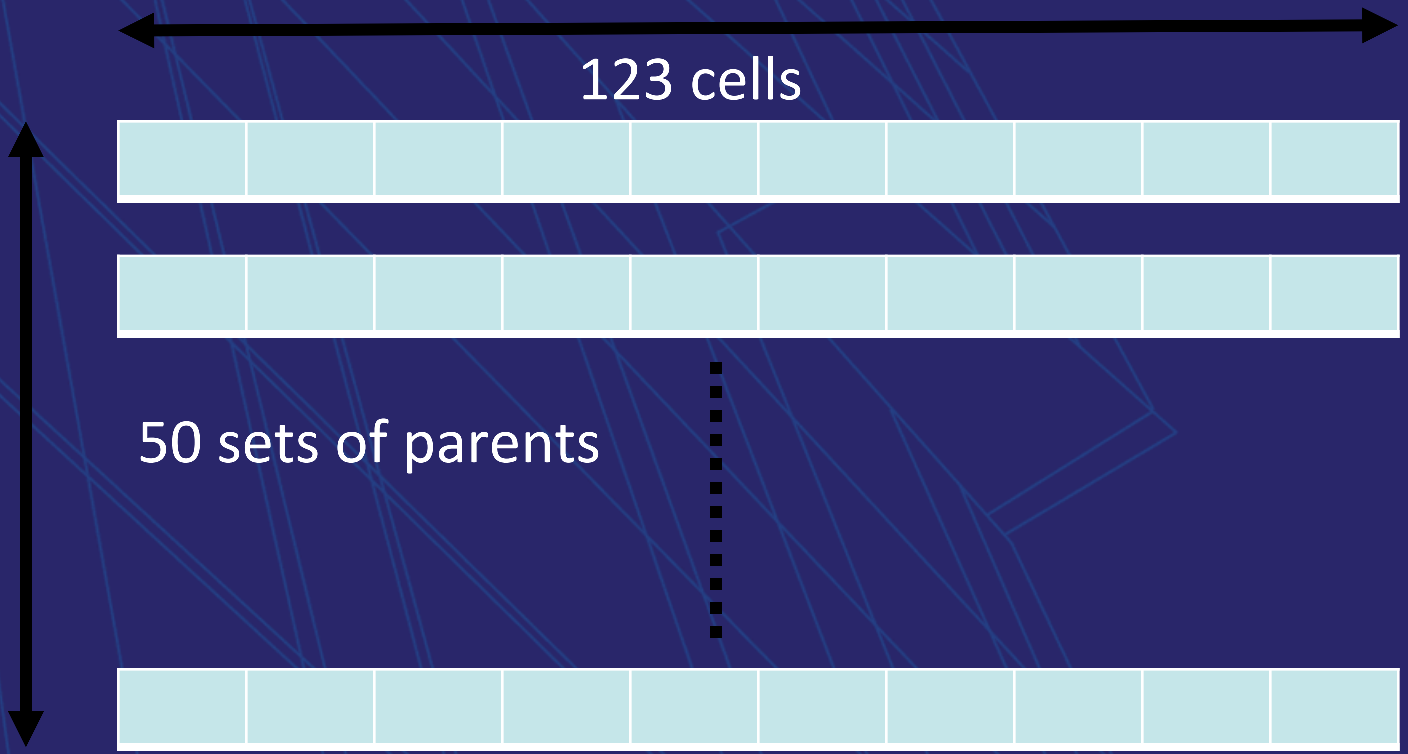
n_i is the n factor for the i_{th} wavelength

Genetic Algorithm

- An optimization method inspired by the evolution of populations of a given species which is a perfect algorithm for spectral-based printer characterization
- Genetic Algorithm consists of 5 steps
  - Initial population
  - Selection
  - Cross Over
  - Mutation
  - Evaluation

Initialize Population

The dot gain data are arranged into an array with 123 columns in an order of Cyan, Magenta, Yellow, and Black with 22 dot gain samples for Cyan, Magenta, Yellow and 21 samples for Black colour in an order from 0 to 100% of the nominal coverage. The 36 spectral *n* factors are attached to the end of array with its initial value set to 1



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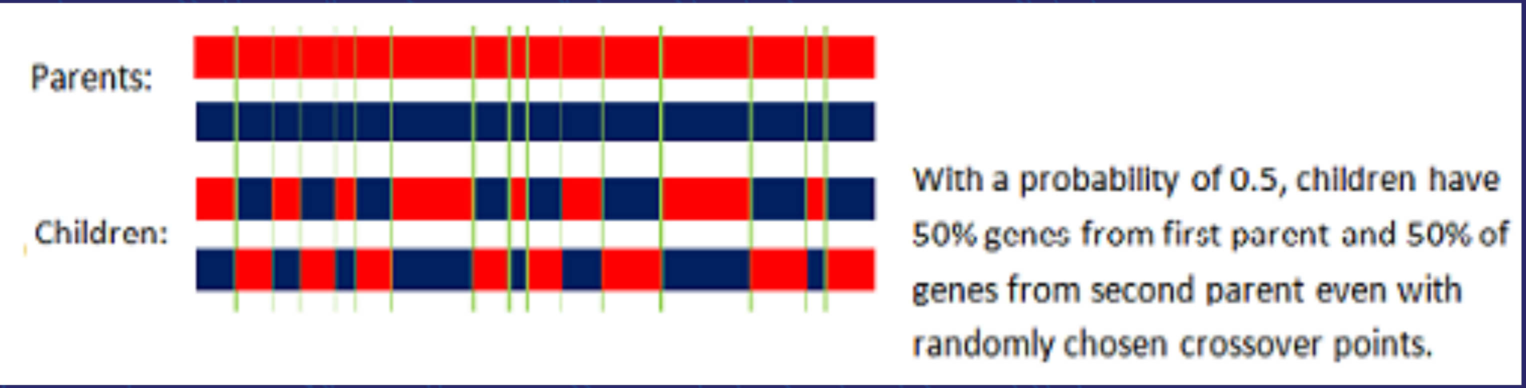
Selection and Cross Over

- The 50 population sets are randomly paired into 25 pairs as the parents of the new generation
- two parents uniformly evaluate each data column (parameter) for exchange with a probability of 50%



Mutation

- Children generation develop their own unique features
- A few rules
  - The dot gain has to equal or larger than original coverage
  - 0% and 100% coverage does not have dot gain
  - *n* is in a range from 0 to 100

Evaluation

- Evaluate the children together with parents
- Rank the them in terms of average delta E
- The top 50 individuals will be selected as population for the next process round and rest of them will be discarded (die out)

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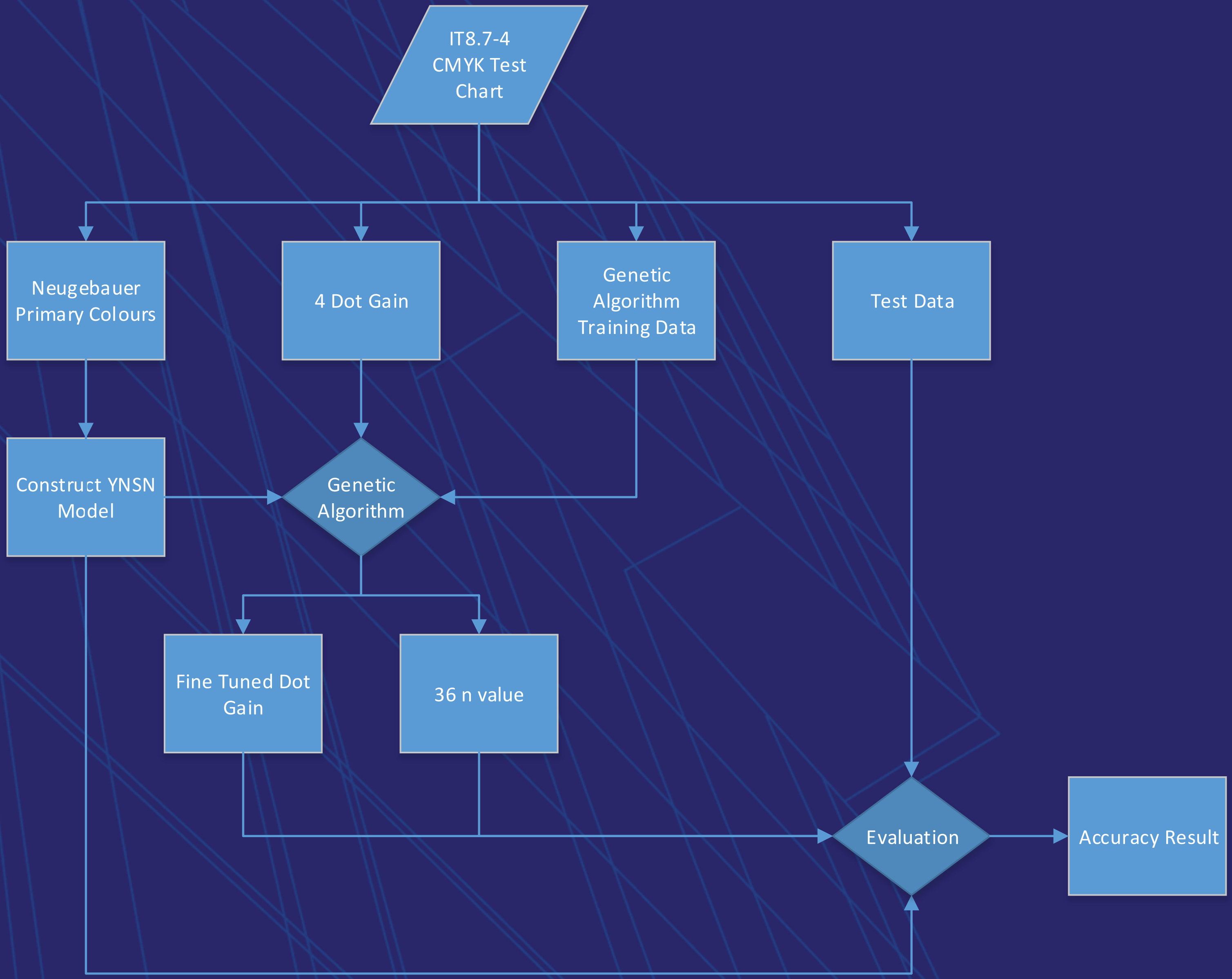

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Data Collection and Experiment Setup

- IT8.7/4 test chart was printed on an offset press with 100lb coated paper in AM screening.
- PressSign software was used to control the ink keys along with an X-Rite eXact to ensure the densities were within GRACoL specifications
- 5 sheets (each sheet has two IT8.7/4 test chart) were measured after 24 hours
- Those 10 measurements were then processed by the α-trimmed mean filter to find out the best 3 measurements in terms of the number counts of data in the median range
- Those 3 measurements were averaged and form a final data
- 1588 unique samples collected, 1271 of them were used as genetic algorithm training data and rest 317 samples were used as a test set to evaluate the model prediction

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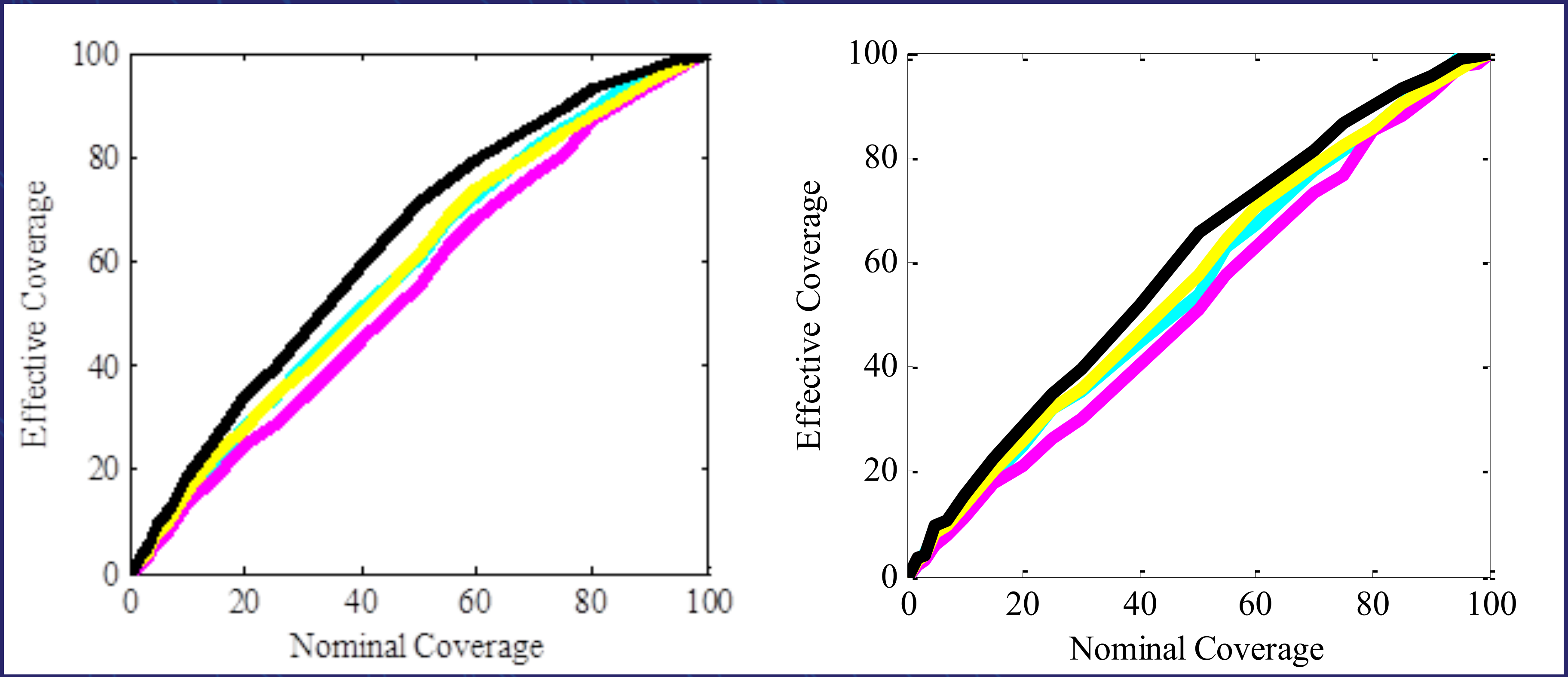
Results



the Original dot gain Curve (left) vs. Genetic Algorithm fine-tuned Curve (right)

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Prediction and Measurement Colour Difference of spectral n vs. Single n

	Spectral n		Single n	
	Best 95% Mean	Worst 5% Mean	Best 95% Mean	Worst 5% Mean
ΔE_{ab}	1.0042	2.7912	1.2361	3.5783
ΔE_{94}	0.6920	1.7924	0.8368	2.2391
ΔE_{00}	0.6877	1.8382	0.8191	2.1911

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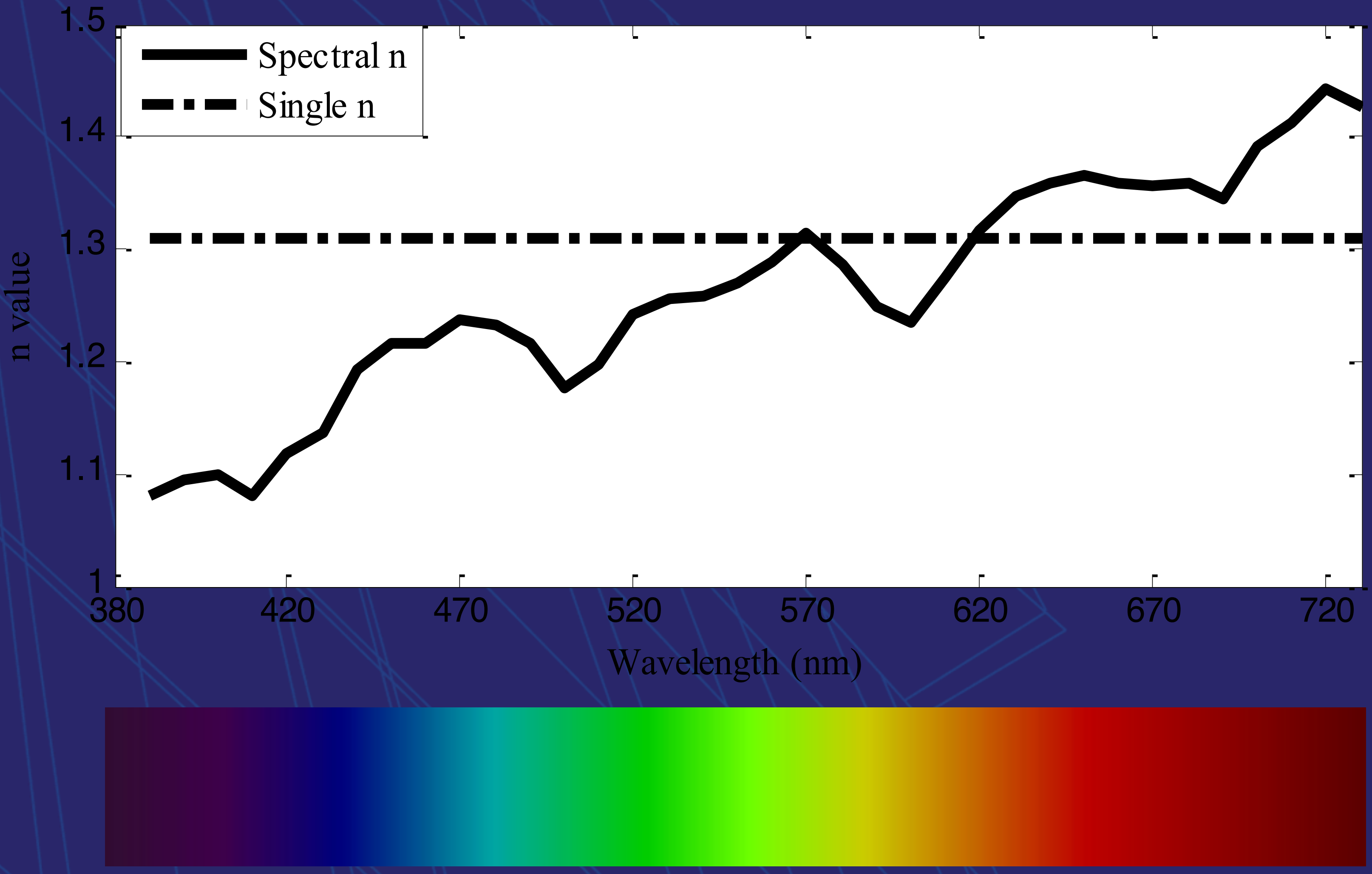
Conclusion



Spectral n values vs. Single n value

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Cont.

- The proposed algorithm fine tune the dot gain curve and obtain the optimized spectral n value at the same time
- The prediction ΔE 5% maximum value in offset press AM screening are smaller than 3

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Thank you

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